UMR - BGPI
Biologie et Génétique
des Interactions Plante-Parasite

Specialization as a joint evolution of host choice and local adaptation

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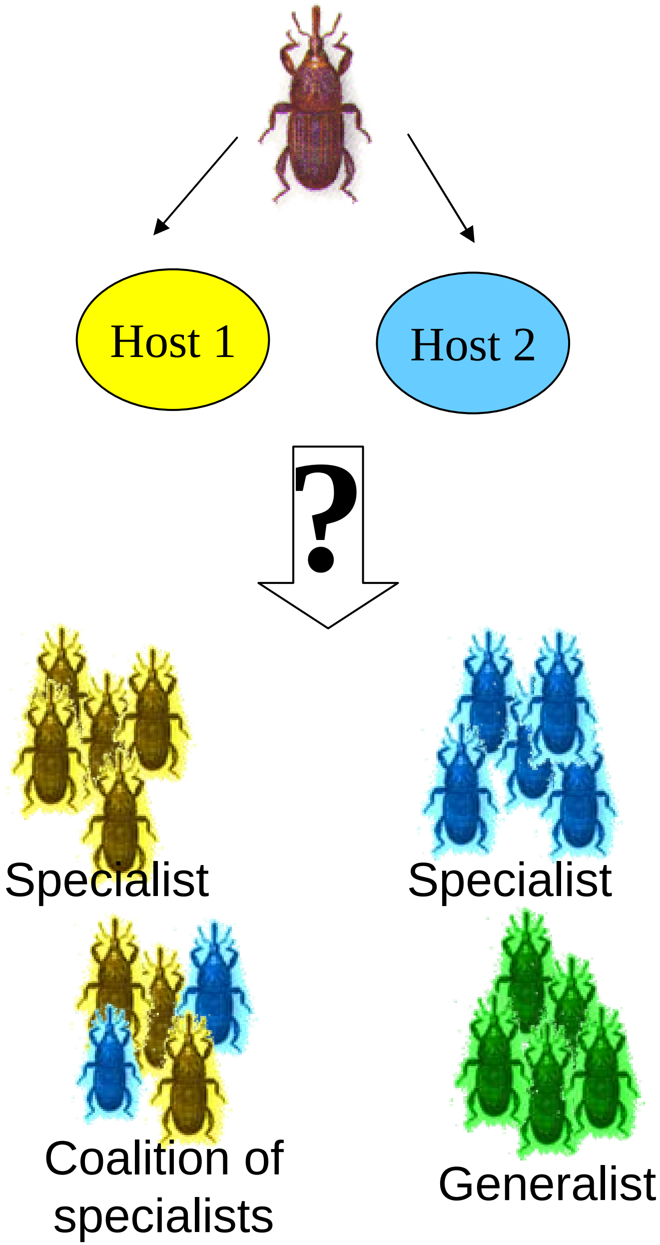
Speciation and specialization in parasites



Speciation requires a source of disruptive selection

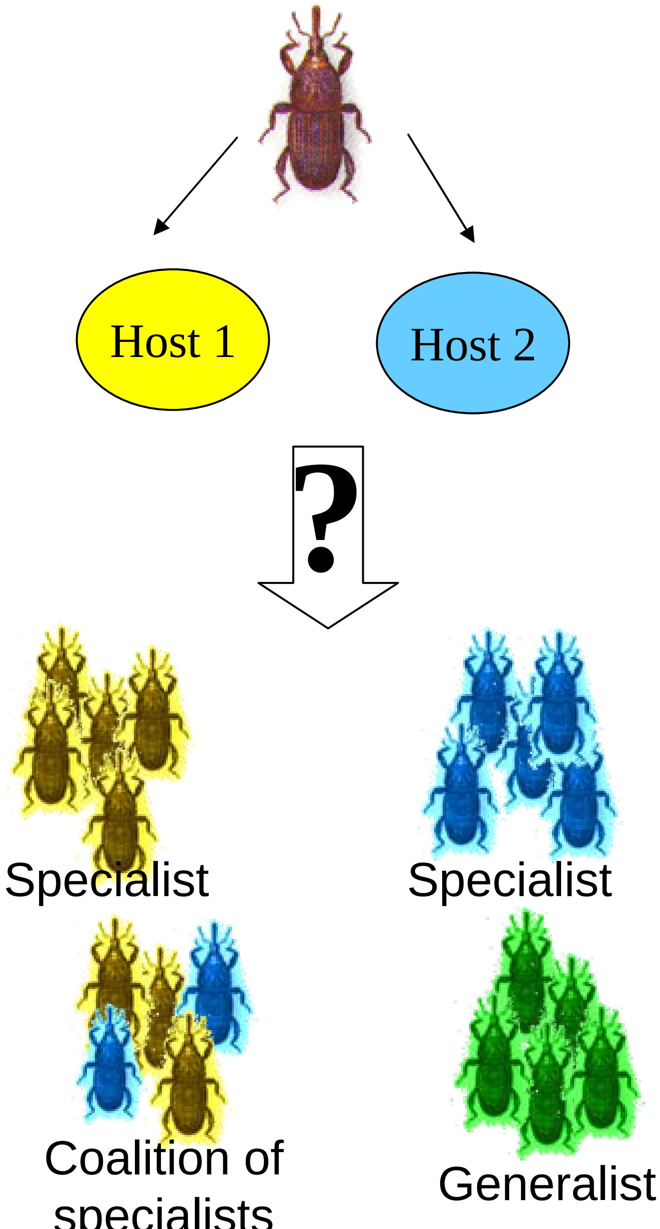
Host diversity may be an important source of disruptive selection in parasites

When does host diversity favor specialization ?

When does specialization associates with parasite diversification ?

When may reproductive isolation evolve ?

Host choice and local adaptation



Specialization

Host choice	Local adaptation
Preference	Performance
Behavioral adaptation	Physiological adaptation
Picky	Specialist
Opportunist	Generalist

Ingredients of a general but simple model of specialisation

- Two hosts (1 and 2) and a (clonal) parasite population

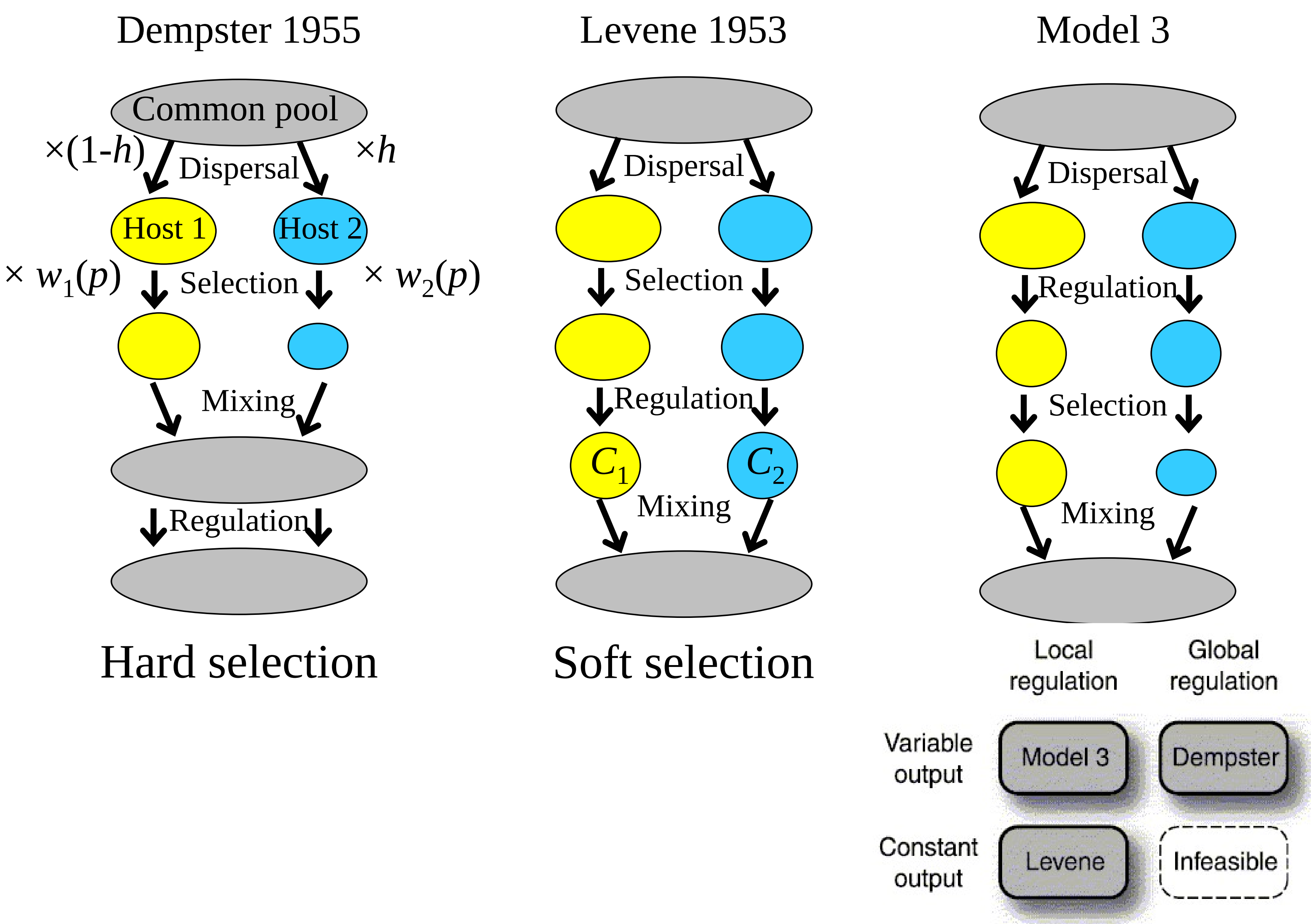
- A local adaptation trait *p* that determine local fitness (fecundity or survival within each host) : $w_1(p)$ and $w_2(p)$

- How individuals distribute among hosts is controlled by a host choice trait *h* (proportion of individuals in host 2 after dispersal stage)

  → may be the result of complex choice mechanisms

- Population density regulation

Three simple life cycles combining dispersal, selection and regulation

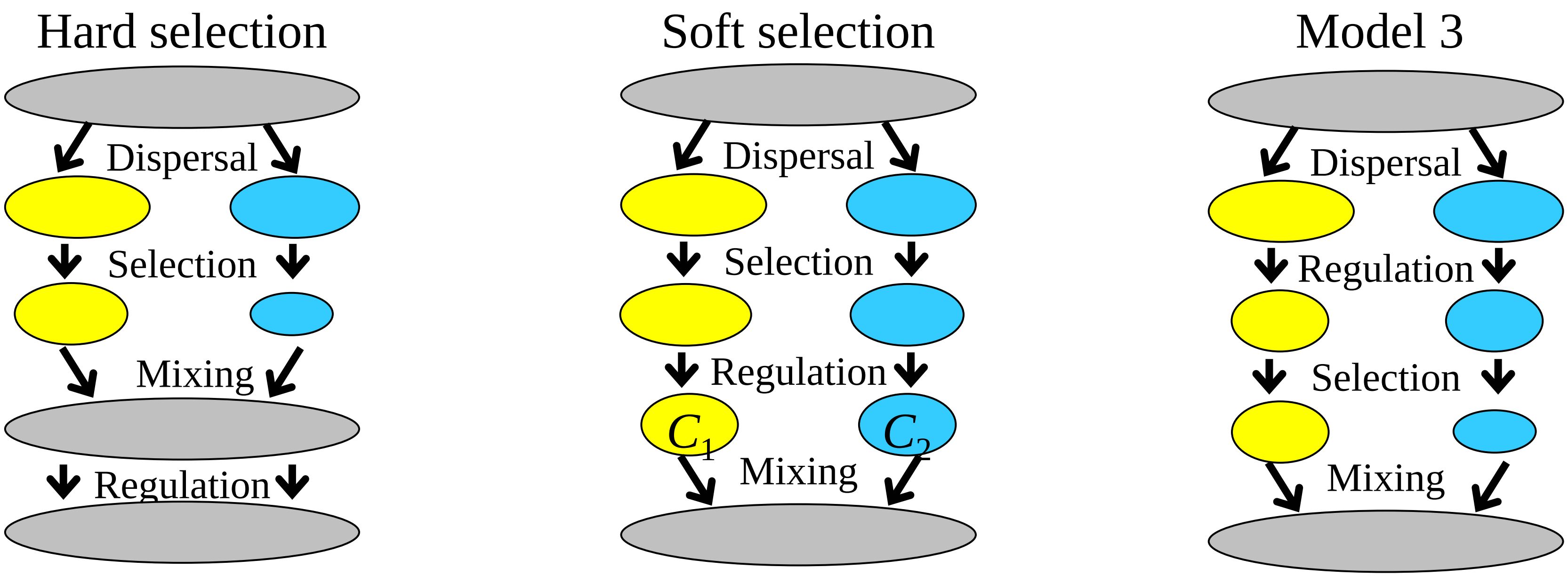


Model analysis

e.g. Metz et al. 1992, Meszéna et al. 2001

Resident parasite population : p, h, N

Mutant parasite population : p_m, h_m, $N_m(t)$

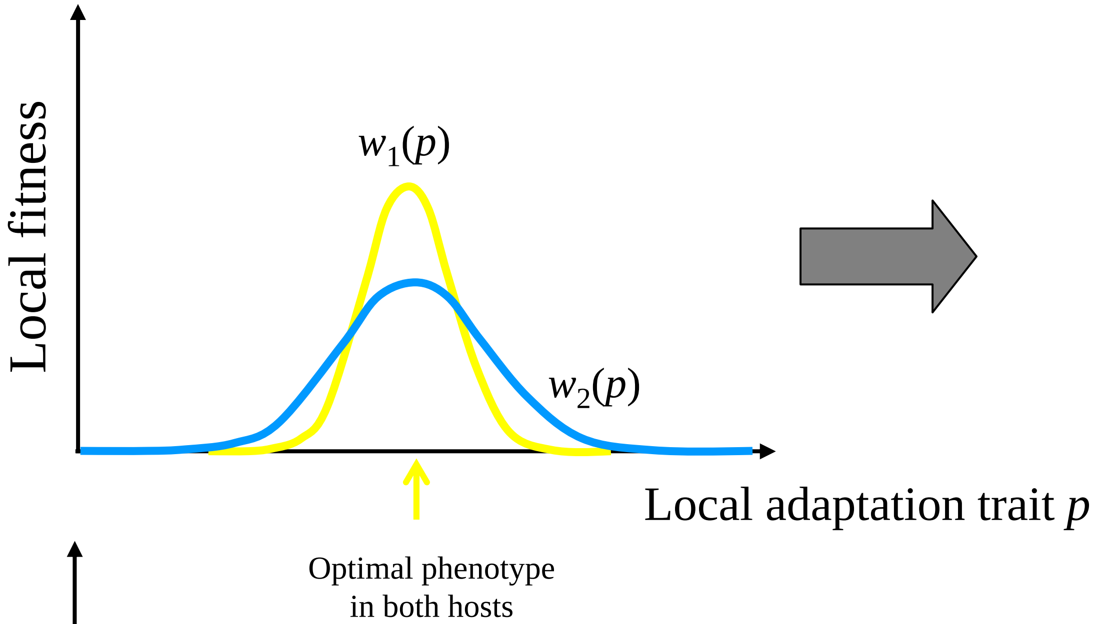


$$s_{p,h}(p_{\mathrm{m}},h_{\mathrm{m}}) = \ln\left(\frac{(1-h_{\mathrm{m}})w_1(p_{\mathrm{m}})+h_{\mathrm{m}}w_2(p_{\mathrm{m}})}{(1-h)w_1(p)+hw_2(p)}\right)$$

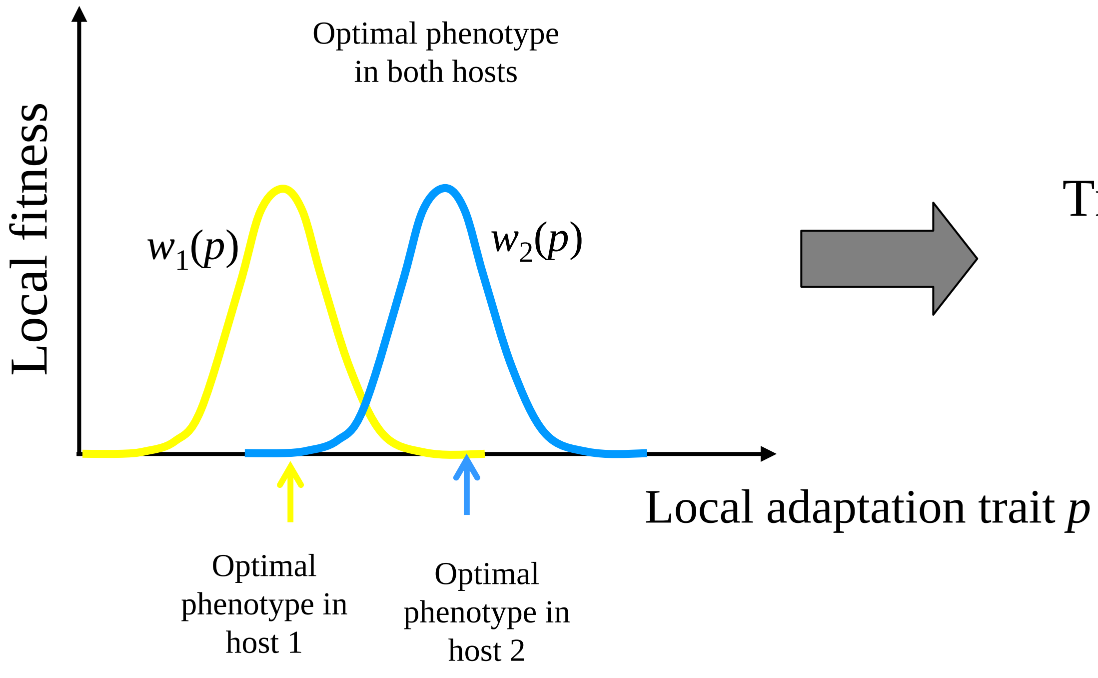
$$s_{p,h}(p_{\mathrm{m}},h_{\mathrm{m}}) = \ln\left(c_1\frac{(1-h_{\mathrm{m}})w_1(p_{\mathrm{m}})}{(1-h)w_1(p)}+c_2\frac{h_{\mathrm{m}}w_2(p_{\mathrm{m}})}{hw_2(p)}\right)$$

$$s_{p,h}(p_{\mathrm{m}},h_{\mathrm{m}}) = \ln\left(\frac{c_1w_1(p_{\mathrm{m}})}{c_1w_1(p)+c_2w_2(p)}\frac{1-h_{\mathrm{m}}}{1-h}+\frac{c_2w_2(p_{\mathrm{m}})}{c_1w_1(p)+c_2w_2(p)}\frac{h_{\mathrm{m}}}{h}\right)$$

Evolution of local adaptation - Something trivial



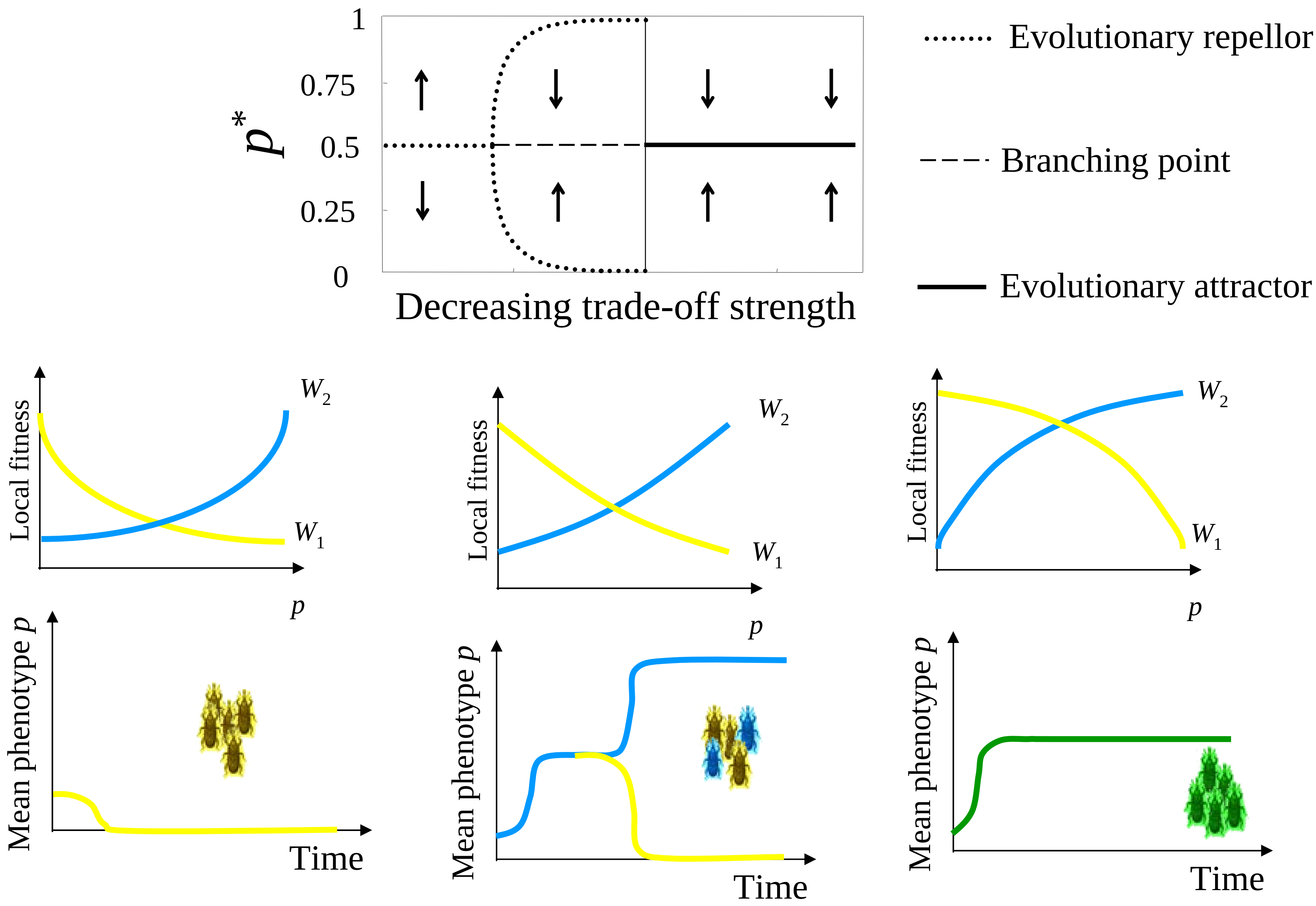
Stabilizing selection toward optimum – no selection for specialization



Trade-off in local adaptation to both hosts – there exists a singular strategy

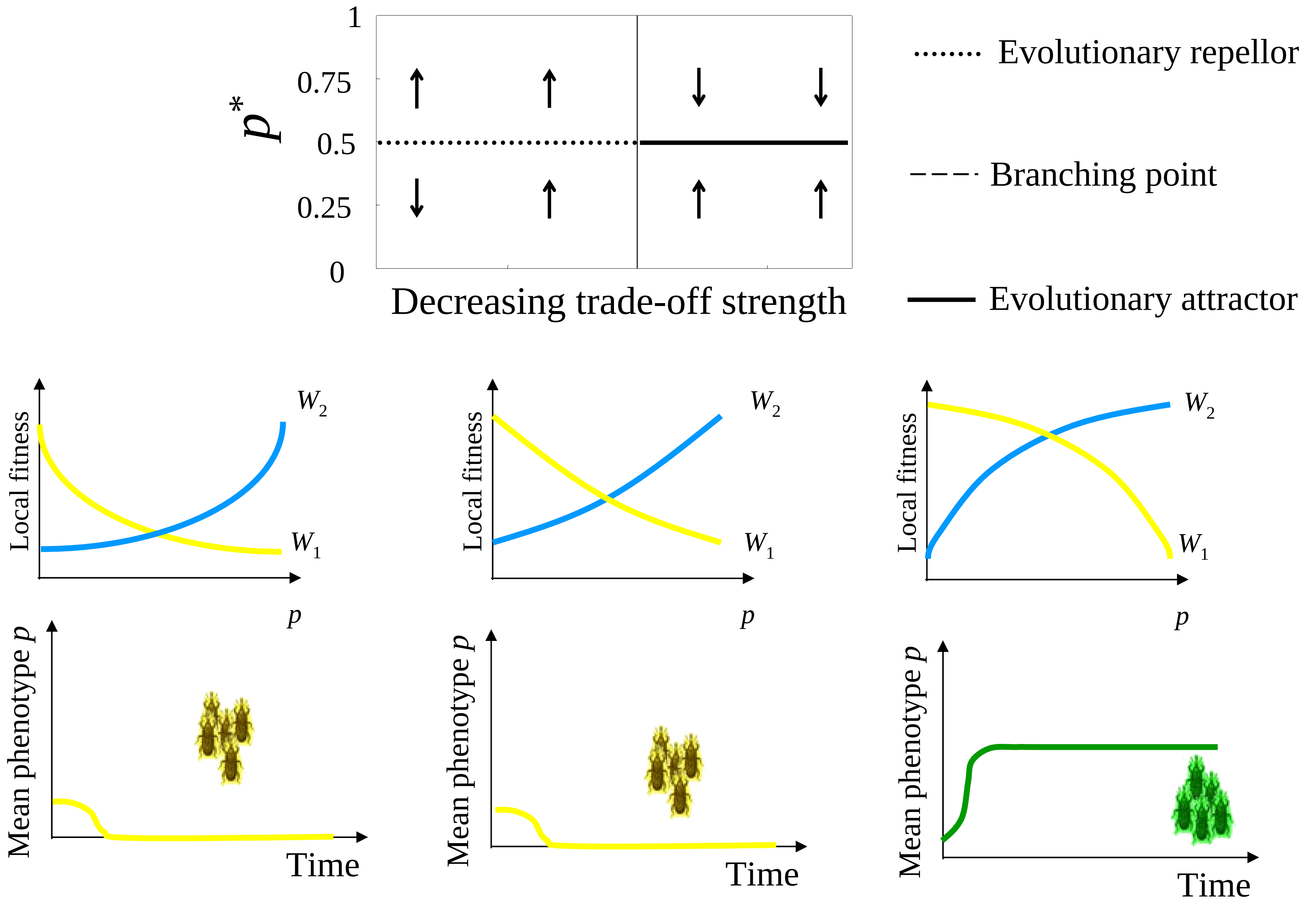
Evolution of local adaptation – Soft selection – Constant host output

Symmetric

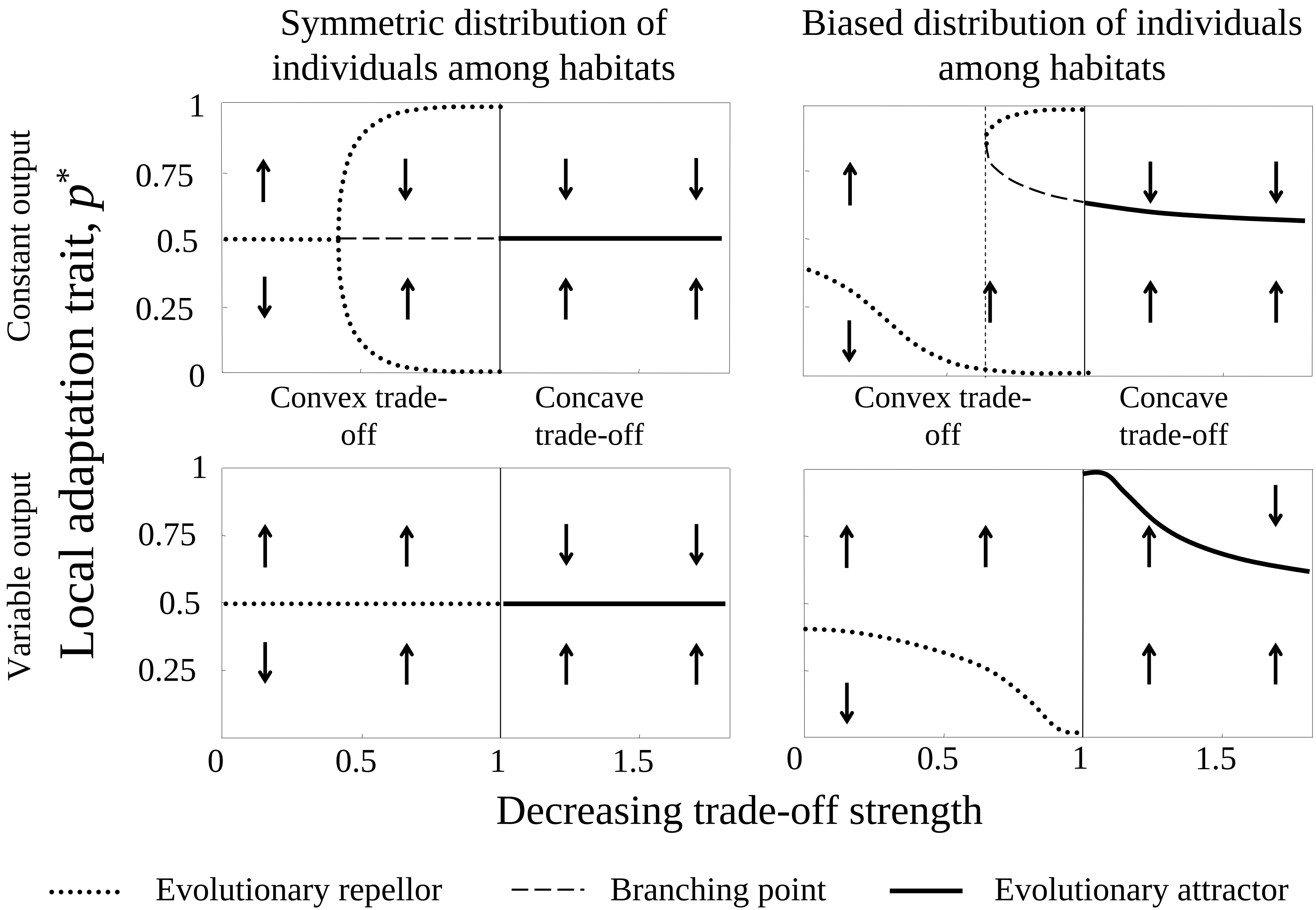


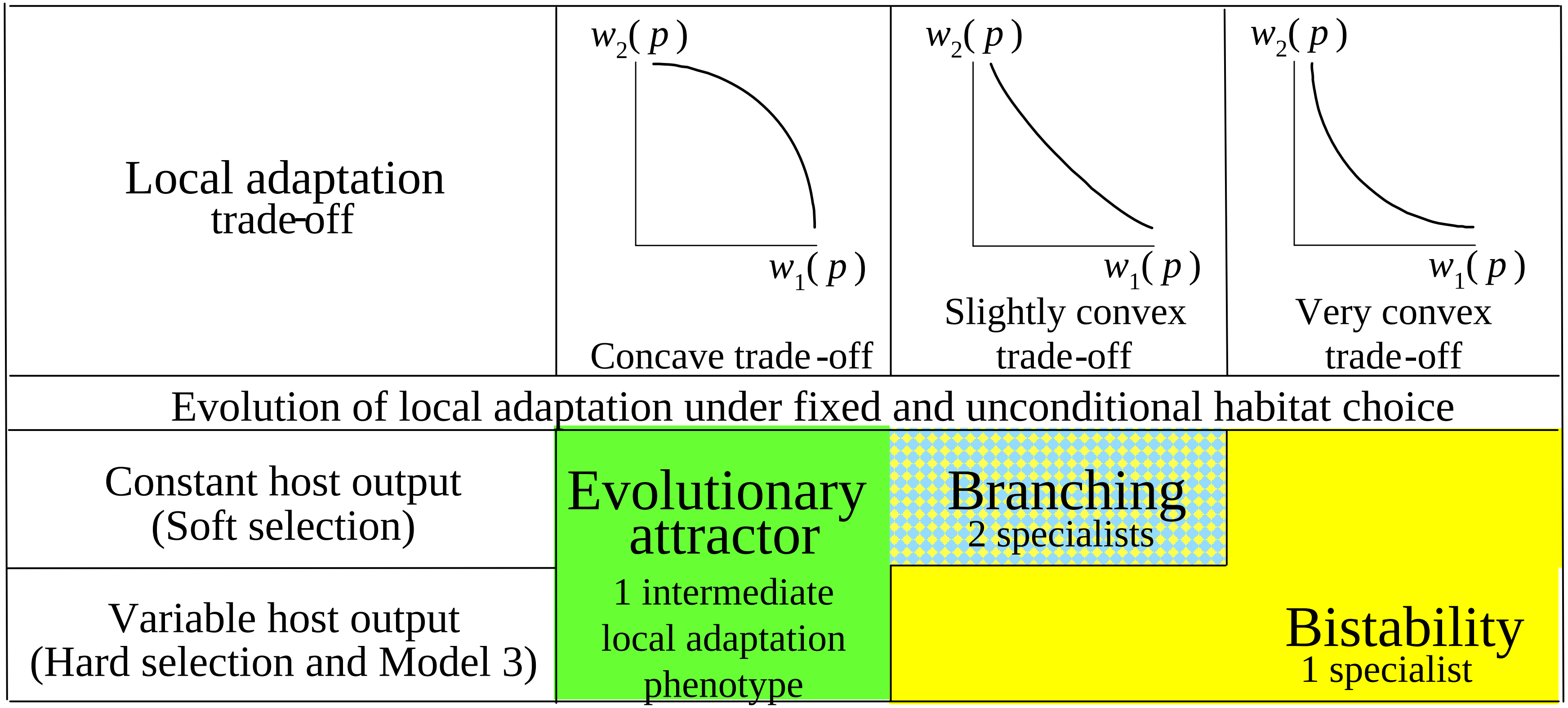
Evolution of local adaptation – Hard selection – Variable host output

Symmetric case



Evolution of local adaptation





Local adaptation trade-off
$w_2(p)$
$w_1(p)$
Concave trade-off
$w_2(p)$
$w_1(p)$
Slightly convex trade-off
$w_2(p)$
$w_1(p)$
Very convex trade-off
Evolution of local adaptation under fixed and unconditional habitat choice
Constant host output (Soft selection)
Variable host output (Hard selection and Model 3)
Evolutionary attractor
1 intermediate local adaptation phenotype
Branching
2 specialists
Bistability
1 specialist

Evolution of host choice alone

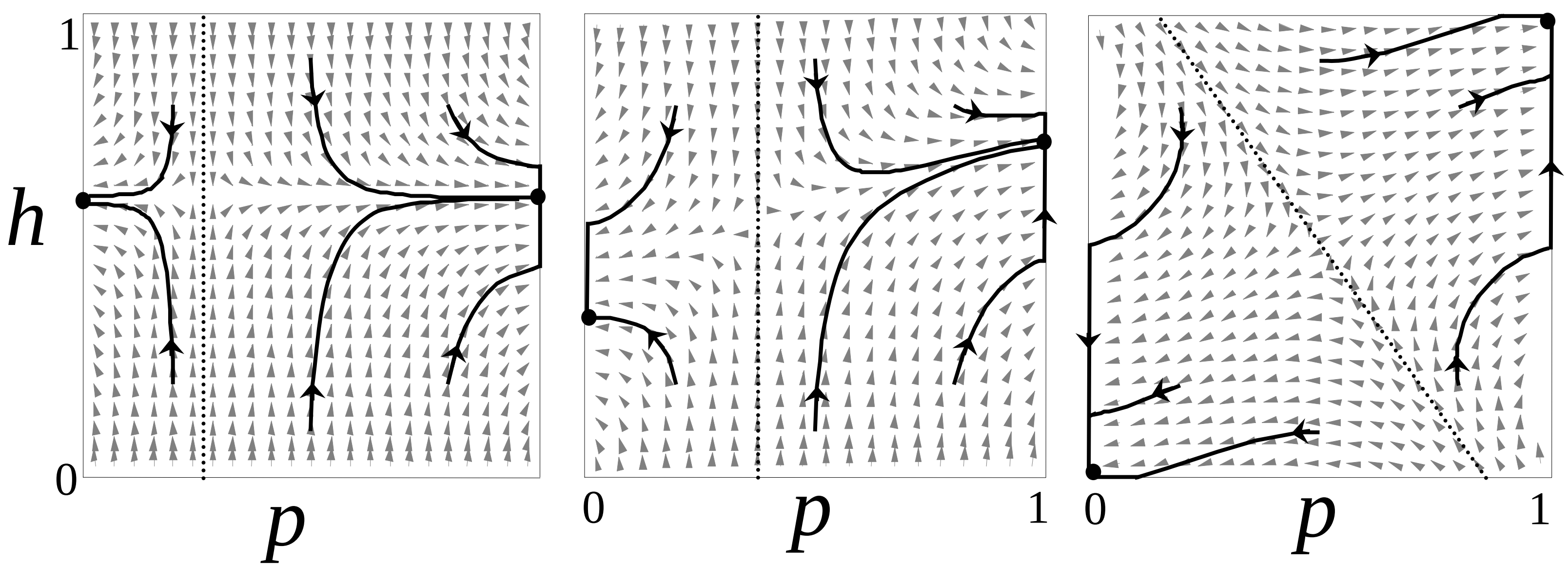
Local regulation		Global regulation
Constant output	Variable output	
Soft selection	Model 3	Hard selection
$h^* = c_2$	$$h^* = \frac{c_2 w_2(p)}{c_1 w_1(p) + c_2 w_2(p)}$$	$h^* = 0 \text{ or } 1$

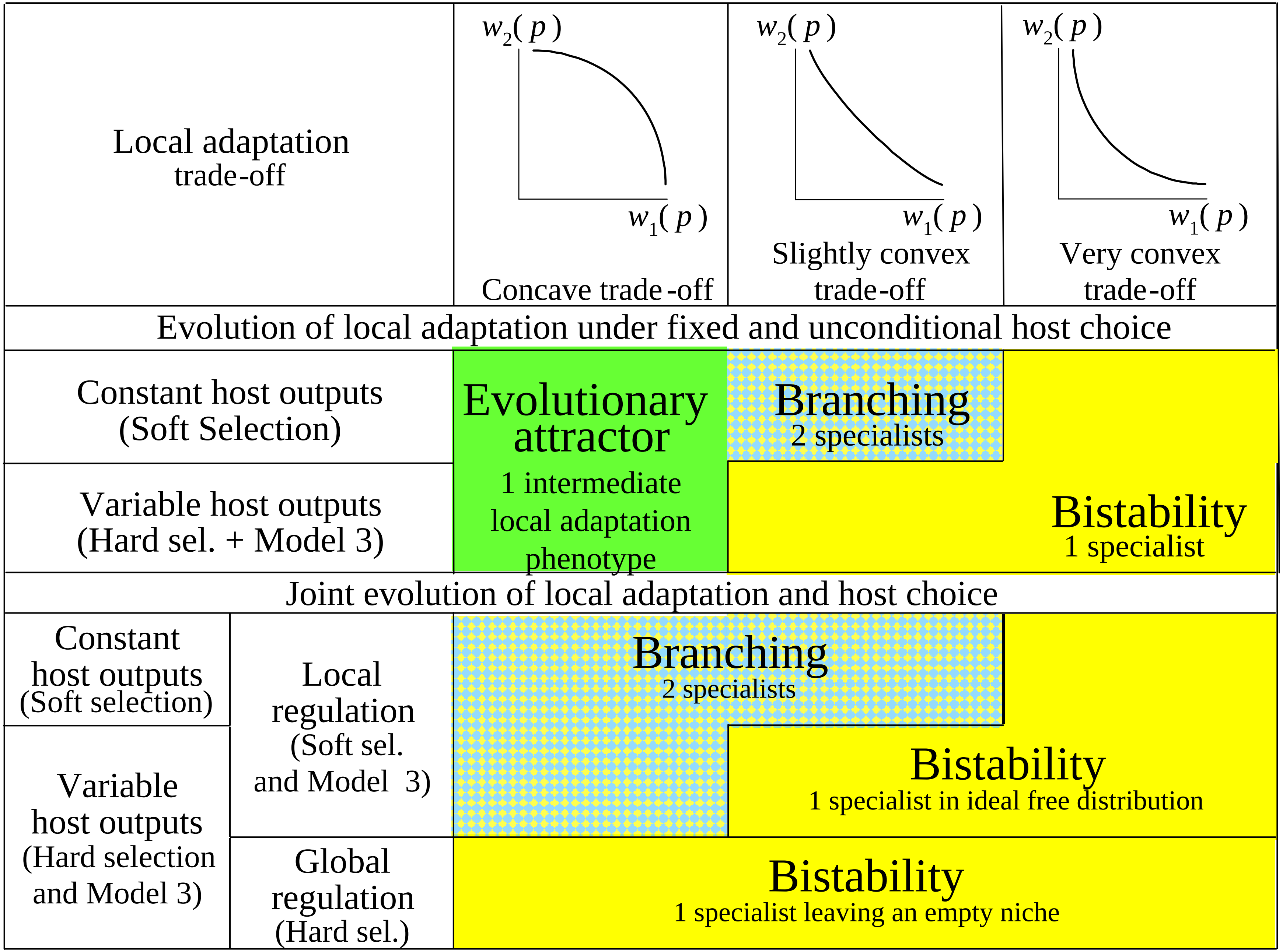
$$\underbrace{h^* = c_2 \qquad h^* = \frac{c_2 w_2(p)}{c_1 w_1(p) + c_2 w_2(p)}}_{\text{Equal competition intensity among hosts (IFD)}}$$

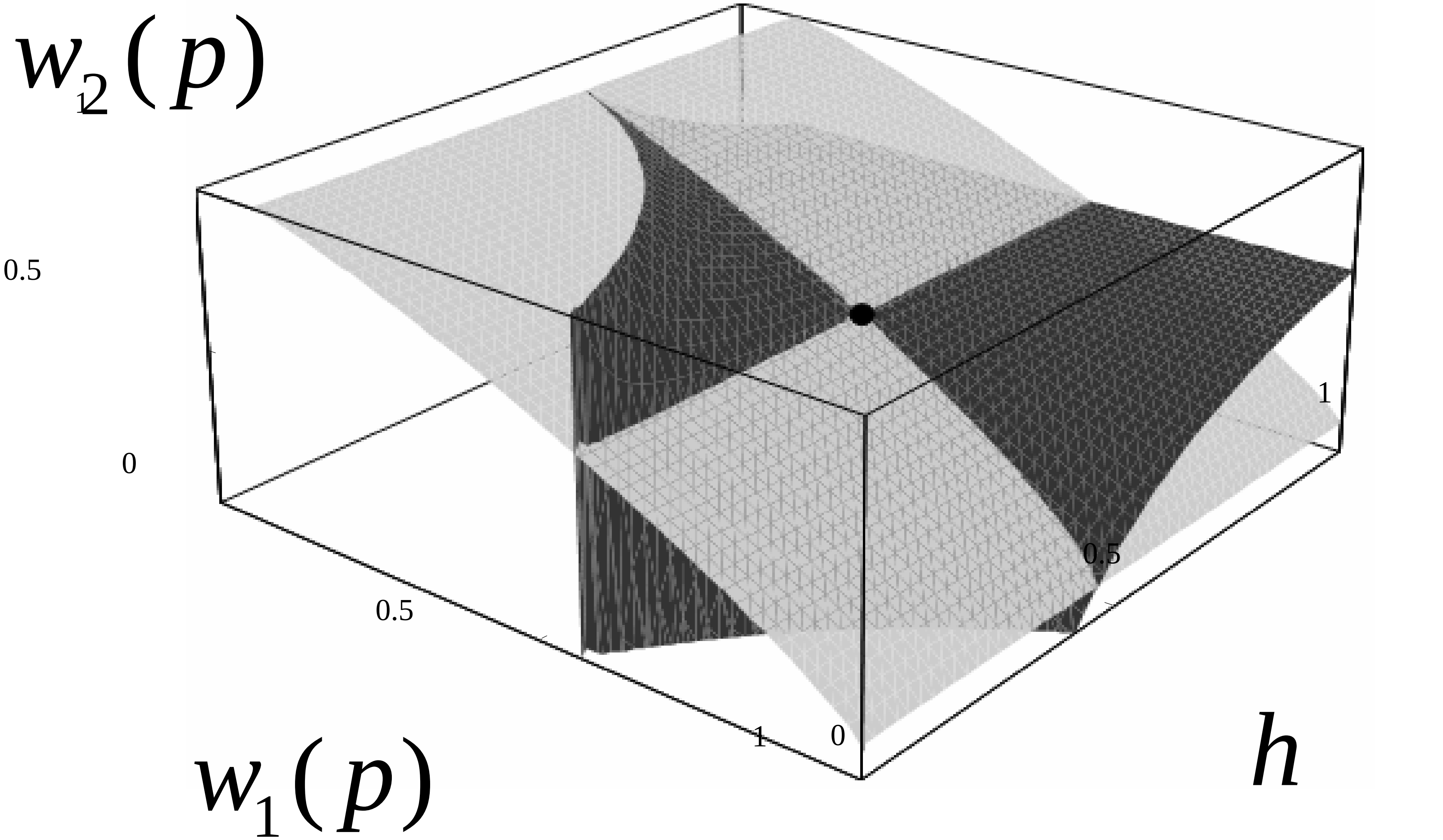
Joint evolution of host choice and local adaptation

- Only two possible outcomes :
  - branching and emergence of a coalition of two extreme specialists
  - bistability and emergence of a single specialist

Local regulation			Global regulation
Constant output	Variable output		
Soft selection	Model 3	Hard selection	




Local adaptation
trade-off
$w_2(p)$
$w_1(p)$
Concave trade-off
$w_2(p)$
$w_1(p)$
Slightly convex
trade-off
$w_2(p)$
$w_1(p)$
Very convex
trade-off
Evolution of local adaptation under fixed and unconditional host choice
Constant host outputs
(Soft Selection)
Variable host outputs
(Hard sel. + Model 3)
Evolutionary
attractor
1 intermediate
local adaptation
phenotype
Branching
2 specialists
Bistability
1 specialist
Joint evolution of local adaptation and host choice
Constant
host outputs
(Soft selection)
Variable
host outputs
(Hard selection
and Model 3)
Local
regulation
(Soft sel.
and Model 3)
Global
regulation
(Hard sel.)
Branching
2 specialists
Bistability
1 specialist in ideal free distribution
Bistability
1 specialist leaving an empty niche


$w_2(p)$
1
0.5
0
0.5
1
0
0.5
1
$w_1(p)$
h

Joint evolution of host choice and local adaptation

Host choice evolution → no generalist

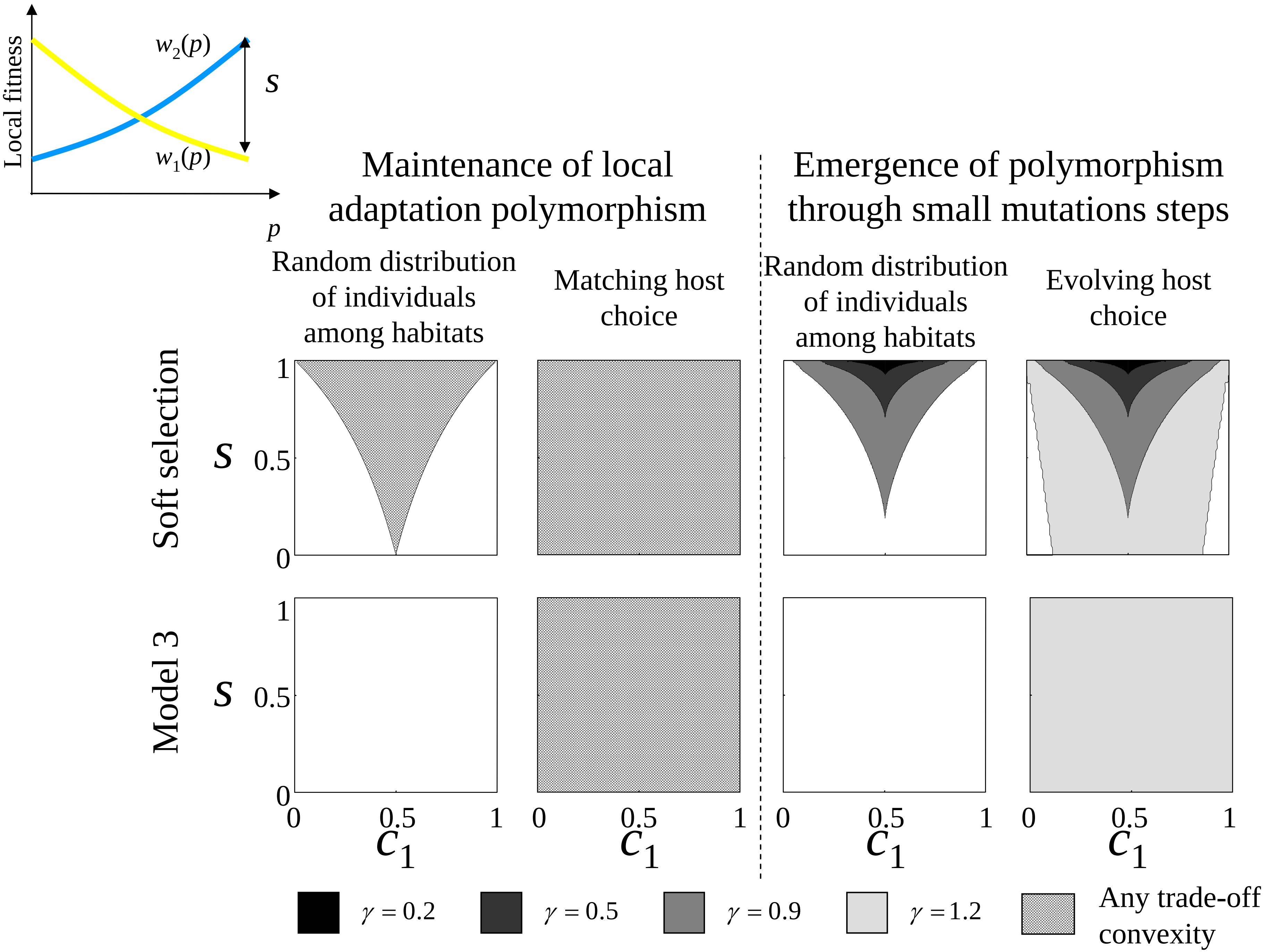
- no temporal variability
- no cost of choosiness
- no constraints (e.g., time limitation)

More realistic population dynamics

- are suprisingly well captured by these qualitative considerations on local vs. global regulation and constant vs. variable output

Evolution through small mutations steps

→ discrepancy with population genetics analysis of these life cycles



Local fitness
$w_2(p)$
$w_1(p)$
s
p
Maintenance of local adaptation polymorphism
Emergence of polymorphism through small mutations steps
Random distribution of individuals among habitats
Matching host choice
Random distribution of individuals among habitats
Evolving host choice
Soft selection
Model 3
s
1
0.5
0
c_1
$\gamma = 0.2$
$\gamma = 0.5$
$\gamma = 0.9$
$\gamma = 1.2$
Any trade-off convexity

Next…

Larger mutation steps = Lesser importance of trade-off shape

Importance of the genetic architecture of local adaptation and host choice

e.g., Hawthorne and Via 2001

Evolution of the genetic architecture of traits under selection in heterogeneous environments

Thank you for your attention